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Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of persons with schizophrenia in China

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2023-076372
Article Type:	Original research
Date Submitted by the Author:	06-Jun-2023
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Keywords:	Psychometrics, PSYCHIATRY, Schizophrenia & psychotic disorders < PSYCHIATRY, Nursing Care

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Title Page

Title: Psychometric validation of the Perceived Stress Scale (PSS-10) among family

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Abstract

Background: The 10-item Perceived Stress Scale (PSS-10) is a widely used measure of perceived stress that has been validated in various populations. The present study examines the reliability and validity of the PSS-10 in a population not previously examined: Chinese family caregivers of persons with schizophrenia.

Methods: A sample of 449 family caregivers of persons with schizophrenia were recruited for psychometric testing of the scale. Internal consistency was tested by calculating Cronbach's α, and test-retest reliability using the intraclass correlation coefficient (ICC). Factor structure was tested using confirmatory factor analysis (CFA), and concurrent validity was examined by investigating the correlation of the PSS-10 to relevant convergent and discriminant measures, including stigma, depression, anxiety, social support, family functioning and caregiving rewarding feelings.

Results: The PSS-10 showed good internal consistency and test-retest reliability, with Cronbach's alpha of 0.79 and ICC of 0.91, respectively. CFA corroborated its priori two-factor structure. In addition, the PSS-10 was correlated in the expected direction with all indicators examined; that is, positively correlated with stigma ($r=0.16$, $p<0.01$), depression ($r=0.54$, $p<0.01$), and anxiety ($r=0.62$, $p<0.01$), and negatively correlated with social support ($r=-0.22$, $p<0.01$), family functioning ($r=-0.30$, $p<0.01$), and caregiving rewarding feelings ($r=-0.33$, $p<0.01$), indicating strong concurrent validity.

Conclusion: The findings indicate that the PSS-10 can be used to measure perceived stress in future research and practice with this and related populations.

Keywords: Perceived Stress Scale; psychometric testing; reliability, validity,

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Confirmatory Factor Analysis

Strengths and limitations of this study

1.This study validated the Chinese version of PSS-10 among family caregivers of

persons with schizophrenia. Its psychometric properties among family caregivers of

individuals with prolonged illnesses, such as with schizophrenia, has not been

examined in Chinese communities before.

2.High test–retest reliability was supported by high ICC of the total score, also

showing the stability of PSS-10 in assessing perceived stress over time.

3.The sample were recruited from 12 urban communities of Changsha city and thus

may not representative of other areas, especially rural communities.

4.The cross-sectional design of the study may preclude testing of sensitivity to change

for the PSS-10.

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Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of persons with schizophrenia in China

Introduction

Schizophrenia is a severe, debilitating chronic psychiatric disorder that causes impairments in cognition, speech, thinking and emotional responsiveness.[1] It impairs individuals' ability to carry out daily activities, including social and occupational functioning [2]. For instance, Wiersma et al. (2000) conducted a 15-year multicenter survey in Europe and found that social dysfunction is widespread and persistent in schizophrenia [3]. Similar findings were also reported in China[4]. Consequently, people with schizophrenia often require ongoing support and care, which in many Asian countries, is often provided by family members [5]. In China, efforts have been made to establish community-based rehabilitation services for individuals with schizophrenia but with family members assuming the major role of caregiving [6]. Caring for people schizophrenia can be a demanding activity that challenges the physical and mental health of family caregivers [7]. As a result, family caregivers may report a high level of stress, which can lead to negative health outcomes and reduced quality of life [8].

Studies have shown that the stress experienced by family caregivers of people with schizophrenia is higher than for caregivers of people with other prolonged illnesses, which is related to higher psychological distress, depression, and anxiety [9, 10]. Caregivers' stress may also result in conflict among family members and increased family dysfunction [7, 11]. These caregivers also report increased perceived stigma due

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to their loved one's mental illness [12-14] as well as insufficient social support [12].

For example, family caregivers may report shame due to disruptive public behaviors of

the family member with schizophrenia and seek to hide them from the public as much

as possible [15, 16]. This can result in social isolation, lack of social support, and social

exclusion, which may result in increased stress. Thus, it is critical that the perceived

stress of family caregivers of persons with schizophrenia be assessed using reliable and

valid measures.

The perceived stress scale (PSS) is one of the most widely used measure for assessing

perceived stress in the world [17, 18]. The PSS [17], measures the degree to which

participants perceive unpredictability, lack of control, or overload in their lives [19].The

original PSS included 14 items (PSS-14),which were further abbreviated into two short

versions: PSS-10 and PSS-4 [17, 19].Although the original PSS-14 showed sufficient

validity and reliability, the shorter version (PSS-10) has superior psychometric

properties and is recommended for research [20]. The PSS-10 has been translated into

various languages and validated in various countries, such as Sweden [21], France [22],

Korea [23], Mexico [24], the United States[25], Arabia [26], Serbia [27], Germany [28],

Viet Nam [29], Brazil [30] and Thailand [31]. The PSS -10 was first translated into

Simplified Chinese (the language of the Chinese mainland) by Yang and Huang in 2003

[32], and approved by its original developer Dr. Cohen [33]. The Simplified Chinese

version of the PSS-10 (C-PSS-10) has been used with including university students [34],

elderly service workers [35] and cardiac patients [36], but its psychometric properties

among family caregivers of individuals with prolonged illnesses, such as with

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schizophrenia, has not been examined in Chinese communities.

The current study was thus conducted to validate the PSS-10 among a Chinese community sample of family caregivers of people living with schizophrenia. Specifically, we examine psychometric properties of PSS-10 for internal consistency reliability, test-retest reliability, factor structure and concurrent validity.

Materials and methods

Participants and procedure

This cross-sectional study used baseline data from a large community sample who agreed to participate in an intervention to support family caregivers of persons with schizophrenia [37]. A total of 449 family caregivers of people with schizophrenia were recruited from 12 communities affiliated with the Changsha Psychiatric Hospital through the "686 program". "686 program" is China's largest demonstration project aimed at integrating hospital and community services for serious mental illness [38]. The Changsha Psychiatric Hospital has long provided mental health services to the 12 communities, including free antipsychotic medicine delivery. Every month, a medical team from the Changsha Psychiatric Hospital went to each community health center to distribute free medicine and run routine health check-ups for registered clients with serious mental illness. Inclusion criteria of family caregivers are: 1) caring for a family member registered in the "686 program" and satisfied the Chinese classification of Mental Disorders (CCMD-3) or the international classification of Schizophrenia (ICD-10) criteria for schizophrenia ; 2) living with the care recipient for at least the last two

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years; 3) aged $\geq$ 18 years; 4) able to read and communicate and complete the questionnaire. Exclusion criteria include: 1) care recipient not registered in the 686 program; 2) care recipient diagnosed with a mental illness other than schizophrenia, such as depression and epilepsy; 3) care recipient living alone; 4) family caregiver has a serious physical or mental illness and thus unable to communicate and complete the interview; 5) family caregiver younger than 18 years. Our final sample size was 449 participants, satisfying the sample size requirement of at least 10 participants for each item in psychometric testing of scales [39].

Data collection was conducted from May 2019 and September 2019. Family caregivers were approached during the free medicine delivery process by the medical team and invited to participate in the study. The medical team explained in detail about the study and referred interested caregivers to our research team. The research team fully explained the research to each family caregiver and fully informed the benefits and risk of participation, as well as their right to withdraw at any time. After providing written informed consent, the caregivers received face-to-face interviews conducted by our research team, and completed a battery of questionnaires. The entire interview required 20-40 minutes, and each participant were reimbursed with RMB 20 yuan (USD $2.80) for completion of the questionnaire.

Instruments

Perceived stress scale (PSS-10)

The 10-item perceived stress scale (PSS-10) is a self-assessed measure of

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psychological stress experienced over the past 30 days. Each answer is scored on a Likert-type scale of 5, ranging from 0 (never) to 4 (very often) .The scale included two factors [40, 41] [42]: "perceived helplessness" consists of 6 negative items (item 1,2,3,6,9,10) assessing the degree of lack of control and negative reactions; "perceived self-efficacy" consists of 4 positive items (item 4,5,7, 8) assessing one's ability to cope with existing stressors [19, 36, 43]. which were reverse coded so that higher score indicating higher stress. The total score of PSS-10 ranges from 0 to 40, with higher scores indicating greater perceived stress and scores of 10 or more indicating moderate to high perceived stress [44]. The Chinese version of PSS-10 used in the present study showed satisfactory internal consistency, with a Cronbach's α of 0.79.

Perceived Devaluation and Discrimination Scale (PDD)

The 12-item Perceived Devaluation and Discrimination Scale (PDD), originated from the Link disease stigma scale series, is a widely used scale for measuring perceived stigma [45-47]. The PDD includes two factors: devaluation (5 items) and discrimination (7items). Each item is scored on a Likert-type scale of 5, ranging from 1 (fully agree) to 5 (totally disagree). Items 1, 2, 3, 4, 8 and 10 were reverse-coded. The total score ranges from 12 to 60, with higher score indicating higher level of perceived stigma [48]. The PDD showed good reliability with a Cronbach's alpha of 0.78 in the original study[45]. The Chinese version of PDD also showed good reliability in other studies[49]. In the current study, the PDD showed acceptable internal consistency with a Cronbach's alpha of 0.70.

Patient health questionnaire (PHQ-9)

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The 9-item Patient Health Questionnaire (PHQ-9) is one of the most widely used screening tools for assessing depressive symptoms over the previous two weeks [50]. Each item is scored on a Likert-type scale of 4, ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 27, with higher score indicating more severe depressive symptoms and a cutoff value of 10 distinguishing depression from it absence. The PHQ-9 was first translated into Chinese by Yeung et al. in 2008, and showed good reliability and validity in the Chinese population [51]. The Chinese version of PHQ-9 shows good internal consistency in the current study, with a Cronbach's Coefficient of 0.93.

Generalized anxiety disorder scale (GAD-7)

The 7-item Generalized Anxiety Disorder scale (GAD-7) is one of the most widely used screening tools for assessing anxiety symptoms during the previous two weeks [52].Each item is scored on a Likert-type scale of 4, ranging from 0 (not at all) to 3 (nearly every day).The total score ranges from 0 to 21, with higher score indicating more severe anxiety symptoms and a cutoff value of 10 distinguishing anxiety and non-anxiety [53]. The GAD-7 was first translated into translated it into Chinese by He X et Al. [54], and showed good reliability and validity in the Chinese population[55]. The Chinese version of GAD-7 showed good internal consistency in the current study, with a Cronbach's Coefficient of 0.95.

Multidimensional scale of perceived social support (MSPSS)

The 12-item perceived social support multidimensional scale (MSPSS) is a widely used scale to measure the strength of support respondents received from three different

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sources: family, friends and significant others [56]. Each item is scored on a Likert-type scale of 7, ranging from 1 (very strongly disagree) to 7 (very strongly agree). The total score ranges from 12 to 84, with higher score indicating higher social support [56, 57]. The MSPSS was first translated into Chinese by Huang L et al in 1996[58]. It showed good reliability with a Cronbach's alpha of 0.85-0.91in the original study [57]. The Chinese version of MSPSS in the current study showed good internal consistency with a Cronbach's Coefficient of 0.95.

Family adaptation, partnership, growth, affection and resolve index scale (APGAR)

The 5-item Family adaptation, partnership, growth, affection and resolve index scale (APGAR) is a widely used scale to measure one's satisfaction with their family functionality. Each item is scored on a Likert-type scale of 3, ranging from 0 (almost never) to 2 (almost always) [59]. The total score ranges from 0 to 10, with higher score indicating higher satisfaction with family functioning. The APGAR has been widely used and well validated in many previous studies, with Cronbach α of 0.86 in the initial rating [60-62]. The Chinese version of APGAR in the current study showed good internal consistency with a Cronbach's Coefficient of 0.95.

Caregiving rewarding feelings (CRF)

The 12-item caregiving rewarding feelings (CRF) measures positive emotions of caregivers during care of a family member with schizophrenia. CRF was initially developed based on qualitative interviews with 30 primary caregivers of people with schizophrenia, then validated in a larger sample. The development and validation of the

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CRF have been described elsewhere [63]. Some sample items include whether caring

for a family member with schizophrenia makes them become "more loving and patient"

"gain a lot of respect " "more active and optimistic, " "more responsible". Each item is

scored on a Likert-type scale of 5, ranging from 1 "totally disagree" to 5 "strongly

agree". The total score ranges from 0 to 36, with higher score indicating more positive

feelings. The CRF in the current study showed good reliability with a Cronbach's alpha

of 0.96.

Statistical analyses

Amos 22.0 (SPSS Inc., Chicago, IL, USA) and IBM SPSS statistics 23 (IBM,

Armonk, New York, America) were used for statistical analyses. The

sociodemographic characteristics of the samples were examined using descriptive

statistics, including mean and standard deviation (SD) for continuous variables,

frequency and percentage for categorical variables.

Internal consistency reliability was assessed using Cronbach α for the total scale of

PSS-10 and its two subscales. A Cronbach α level of ≥ 0.70 indicates good reliability

[64]. Test-retest reliability was calculated in a subsample of these participants (n =25)

who were randomly assessed again 2 weeks later to allow calculation of the intraclass

correlation coefficient (ICC). An ICC value of ≥ 0.75 indicates good test-retest

reliability[65, 66].

Factor structure was evaluated by Confirmatory factor analysis (CFA) to test the a

priori two-factor structure for the PSS-10. Kline (2005) and Byrne (2001) suggested

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the following CFA goodness-of-fit measures for model fit evaluation: goodness-of-fit index (GFI) >0.9, adjust goodness-of-fit index(AGFI)>0.9, comparing fit index (CFI)>0.9, non-normal fit index (NNFI)>0.90, standard root mean square residual (SRMR)<0.08, root mean square error of approximate (RMSEA)<0.08, Tucker-Lewis Index (TLI)>0.9 [67-69].

Concurrent validity was assessed using Pearson product–moment correlations with an expected significant positive correlation with the PDD, PHQ-9, and GAD-7; and expected significant negative correlations with the MSPSS, APGAR, and CRF.

Results

Sample demographics

Table 1 shows the socio-demographic characteristics of the sample. The caregivers had a mean (SD) age of 60.90 (12.28) years. Most caregivers were spouses or parents (80.18%), not employed (85.6%), of middle and high school education (61.5%), and married/cohabited (75.7%). Over half were female (54.1%), and had an annual income of lower than 20,000 RMB (56.6%).

Reliability

Internal consistency reliability, as measured by Cronbach's alpha coefficient, was 0.79 for the total score of the PSS-10, 0.88 for the subscale of perceived helplessness, and 0.79 for the subscale of perceived self-efficacy. These results indicate good internal consistency reliability. The ICC for the total score was 0.91 (p < 0.001), exceeding the recommended standard of 0.70 and indicating good test-retest reliability.

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Factor structure

Confirmatory factor analysis (CFA) was used to test the a priori two-factor structure of PSS-10. The two-factor structure was supported by the following goodness-of-fit statistics:

$\chi 2$ /df= 2.628<3, p < 0.001; GFI=0.963; AGFI=0.937; CFI=0.972; NNFI=0.961; TLI=0.961; RMSEA=0.061; SRMR=0.061. All these indexes indicated good or acceptable model fit. Figure 1 shows visualization of the two-factor model. Table 2 displays the means, standard deviations, and factor loadings of all 10 items. All items loaded well in their respective domains, with factoring loading ranging from 0.61-0.83 for subscale of perceived helplessness, and 0.60-0.83 for the subscale of perceived self-efficacy. The correlation between the two scales of PSS-10 was 0.006 (p<0.001).

Concurrent validity

The concurrent validity of PSS-10 was verified using correlational analysis. As shown in Table 3, the total score of the PSS-10 and its two subscales were positively correlated with PDD (r: 0.07 to 0.16), PHQ-9 (r: 0.17 to 0.54), and GAD-7 (r: 0.14 to 0.62).The scores of PSS-10 and its two subscales were significantly negatively correlated with MSPSS-12 (r: - 0.24 to - 0.13), APGAR-5 (r: - 0.35 to - 0.19), and CRF-12 (r: - 0.45 to - 0.33). All the correlation coefficients were significant at p = 0.01, which confirmed the concurrent validity of PSS-10.

Discussion

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PSS-10 is one of the most widely used scales for stress assessment and has been translated into more than 20 languages [20]. This study validated the Chinese version of PSS-10 among family caregivers of persons with schizophrenia. Overall, the PSS-10 showed good internal consistency and test–retest reliability, and confirmatory factor analysis supported the a priori two-factor structure with favorable model fit indices. Concurrent validity was also supported by significant positive correlations with stigma, depression, and anxiety, and significant negative relationships with social support, family functioning, and caregiving rewarding feelings. Thus, the PSS-10 demonstrated psychometrically sound properties for assessing the subjective experience of stress among caregivers of people with schizophrenia.

The Cronbach α value for the total scale and two subscales of PSS-10 exceeded the recommended 0.70. indicating high internal consistency reliability. This finding is consistent with previous studies of Chinese [33-35] and non-Chinese samples, such as Japan [70], South Korea [71], the United States [72], and Sweden [21]. High test–retest reliability was supported by high ICC of the total score, also showing the stability of PSS-10 in assessing perceived stress over time. However, test–retest reliability findings must be interpreted with caution because of the relatively small sample size. Future research may benefit from using a larger sample size to examine test–retest reliability.

Confirmatory factor analysis validated the a priori two-factor structure of PSS-10: perceived helplessness and perceived self-efficacy. Perceived helplessness includes 6 negative phrasing items (item 1,2,3,6,9,10) that reflect a lack of control and negative emotions, while perceived self-efficacy includes 4 positive phrasing items (item 4,5,7,

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8) that reflect confidence in dealing with things and positive emotions. The favorable

model fit indices show the two-factor structure is good and the fit acceptable. Also, in

line with our theoretical hypothesis, all items of PSS-10 had high factor loadings on its

specified factors, further showing the robustness of two-factor structure of the PSS-10.

The two-factor structure found in the current sample is consistent with previous

research on the use of PSS-10 in other populations, such as university students [34, 52,

73], general adult samples [33, 35, 74-76], and clinical patients [36, 40]. What is

noteworthy is that there has been wide debate about whether PSS-10 should be used as

a full scale [19, 30, 33], or two separate subscales. Some researchers believe that the

two subscales measure different components of the stress experience [76] and have

suggested using them separately [77]. In the current study, the low correlation

coefficient of 0.09 between the two subscales implies that the two factors may be

unrelated and reflect different domains of perceived stress, which is consistent with the

original developer-Cohen's conceptualization of the scale (1988). It seems that the PSS-

10 can be used either as a whole scale or as two subscales depending on the research

questions under study.

The concurrent validity of PSS-10 was demonstrated by its significant positive

correlations with PDD, PHQ-9, and GAD-7, as well as significant negative correlations

with MSPSS12, APGAR, and CRF. This finding is consistent with previous studies

showing a negative health outcomes related to high perceived stress among caregivers

of people with schizophrenia, such as increased depression and anxiety, decreased

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family functioning and rewarding feelings, which may be related to their increased feelings of stigma and reduced social support [10, 12, 25] Understanding the relationship between perceived stress and health outcomes of family caregivers may guide further family caregiver interventions.

The present study also had several limitations. First, the sample were recruited from 12 urban communities of Changsha city and thus may not representative of other areas, especially rural communities. Future multi-center studies may address this issue. Second, the cross-sectional design of the study may preclude testing of sensitivity to change for the PSS-10; subsequent longitudinal research should examine this. Third, test-retest reliability was based on a relatively small sample size, which may be further confirmed in a larger sample.

Conclusion

In summary, the PSS-10 has good psychometric characteristics assessing the perceived stress of family caregivers of people living with schizophrenia, including good internal consistency, test-retest reliability, and concurrent validity. Confirmatory factor analysis confirmed the a priori two-factor structure: perceived helplessness and perceived self-efficacy in the current population. Our findings provide reliable evidence for the use of PSS-10 in future studies to assess perceived stress among caregivers of people living with schizophrenia, and potentially, other caregiving samples.

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Acknowledgements

Competing interests

The authors declare that they have no competing interests.

Authors' contributions:

All authors have made substantial contributions to the study conception and design, data collection and analysis, as well as to the development and editing of the manuscript. XT, SJX and YY contributed to the conception and design of the study, XT, SJX, FZ, DW, XL and YY contributed to the research conduction and data collection, XT, SJX and FZ contributed to data analyses, DW, XL, XT, SJX and YY contributed to data interpretation. XT and SJX drafted the article while XT, XSJ, FZ, DW, XL and YY critically appraised it and revised it. All authors approved the final version of manuscript for submission and publication and agreed to be accountable for all aspects

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of the work.

Ethics approval and consent to participate

The Institutional review board of Xiangya School of Public Health Central South University (No.: XYGW-2019-029) has approved and regulates the ethical execution of this research.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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Table 1. Demographic characteristics of the participants (N = 449)

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Characteristics		M (sd)/N (%) N=449
Age(years)	18-59	169 (37.6)
	60-100	280 (62.4)
	Mean (SD)	60.90 (12.28)
Gender	Male	206 (45.9)
	Female	243 (54.1)
Occupation	Employed	65 (14.4)
	Not employed	384 (85.6)
Education	Primary and below	130 (29.0)
	Middle and high	276 (61.5)
	College and above	43 (9.5)
Marital status	Single	19 (4.2)
	Married/cohabited	340 (75.7)
	Else(divorced/separated/widowed)	90 (20.0)
Kinship	Parents	254 (56.57)
	Spouse	106 (23.61)
	Children	29 (6.46)
	Siblings	49 (10.91)
	Other	11 (2.45)
Income (RMB/year)	20000 or less	254 (56.6)
	20001-40000	99 (22.0)
	40000 or greater	96 (21.4)

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Table 2.   Descriptive statistics and factor loadings of the PSS-10（N=439）

Items	Mean （SD）	Factor loading
Factor 1: Crisis perception (a = 0.88)		
1. Been upset	1.75 (1.09)	0.78
2. Unable to control	1.80 (1.20)	0.83
3. Nervous and stressed	2.02 (1.15)	0.81
6. Could not cope	1.78 (1.09)	0.71
9. Been angered	1.74 (1.24)	0.61
10. Could not overcome	1.80 (1.20)	0.69
Factor 2: Coping ability perception (a = 0.79)		
4. Felt confident	1.68 (1.23)	0.60
5. Going your way	2.30 (1.17)	0.62
7. Control irritations	1.74 (1.11)	0.75
8. On top of things	1.91 (1.18)	0.83

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Table 3 Correlations of PSS-10 and its two subscales with other variables

Variables	1	2	3	4	5	6	7	8	9
1. PSS-10	1.00								
2. Perceived helplessness-sub	0.88**	1.00							
3. Perceived self-efficacy-sub	0.51**	0.09	1.00						
4.PDD	0.16**	0.14**	0.07	1.00					
5. PHQ-9	0.54**	0.54**	0.17**	-0.02	1.00				
6. GAD-7	0.62**	0.65**	0.14**	0.01	0.72**	1.00			
7.MSPSS-12	-0.22**	-0.13**	-0.24**	-0.31**	-0.11*	-0.09	1.00		
8.APGAR-5	-0.30**	-0.19**	-0.35**	-0.27**	-0.18**	-0.17**	0.56**	1.00	
9.CRF-12	-0.33**	-0.15**	-0.45**	-0.27**	-0.12**	-0.08	0.54**	0.66**	1.00

&Spearman correlation using pairwise deletion for missing values

*P< 0.05, ** P<0.01

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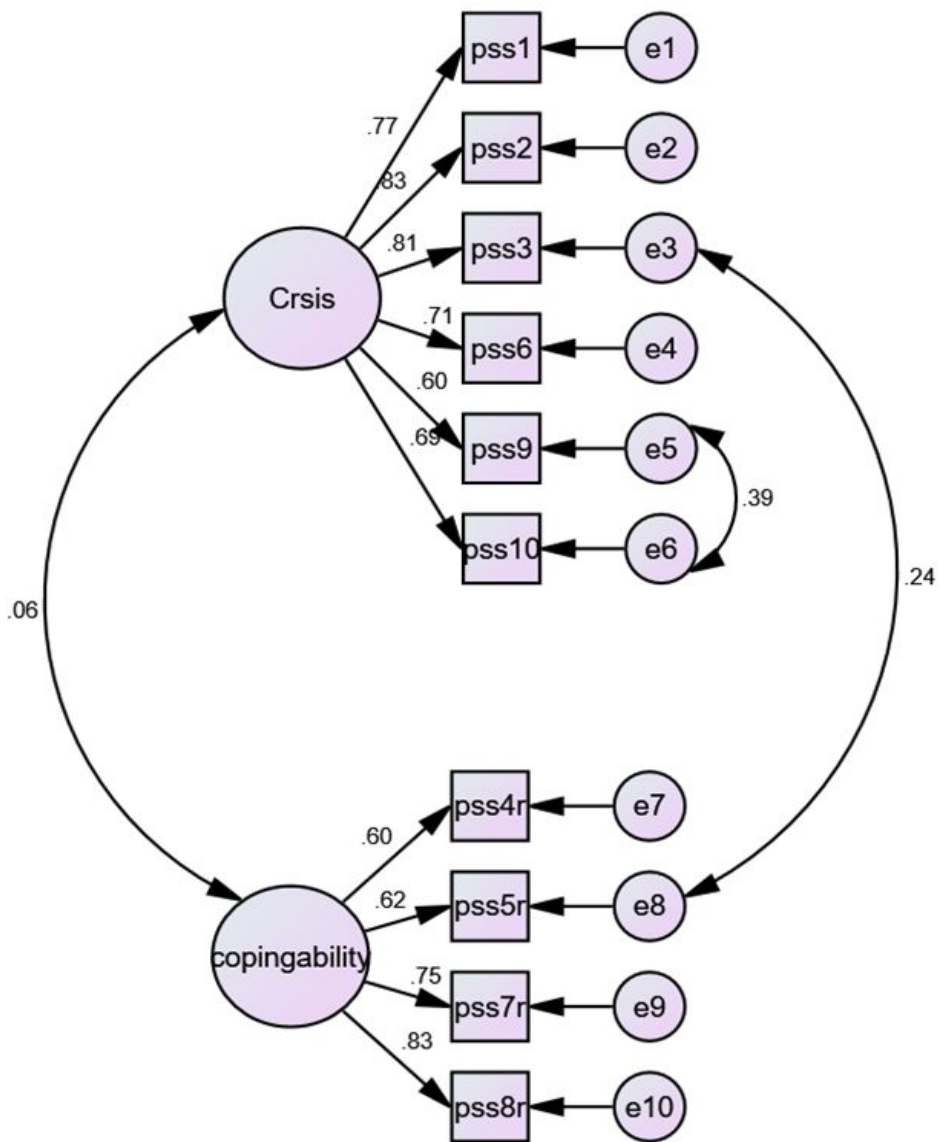51
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FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10)（N=439）

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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-8
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-13
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	13-14
		(*b*) Describe any methods used to examine subgroups and interactions	13-14
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	13-14
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	14
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	14-15

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	14-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14-15
Discussion			
Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	19

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of people with schizophrenia in China

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Title Page

Title: Psychometric validation of the Perceived Stress Scale (PSS-10) among family

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Abstract

Background: The 10-item Perceived Stress Scale (PSS-10) is a widely used measure of perceived stress that has been validated in various populations, yet with inconsistent results on its factor structure. The present study examines the reliability and validity of the PSS-10 in a population not previously examined: Chinese family caregivers of persons with schizophrenia, with a focus on factor analysis.

Methods: A sample of 449 family caregivers of persons with schizophrenia were recruited for psychometric testing of the scale. The factor structure of PSS-10 was tested by randomly dividing the sample into two groups for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The scale was further tested for internal consistency, test-retest reliability, convergent validity, discriminant validity, and concurrent validity.

Results: EFA extracted two factors: perceived helplessness with 6 negative phrasing items and perceived efficacy with 4 positive phrasing items. CFA confirmed the structure of two factors with satisfactory model fit indices. Convergent validity was supported by high standard regression weight (SRW=0.78-0.92), average variance extracted (AVE=0.79-0.81), and composite reliability (CR=0.88-0.94), while discriminant validity was confirmed by higher AVE estimates than the squared inter-construct correlations. The PSS-10 showed good internal consistency and test-retest reliability, with Cronbach's alpha of 0.79 and ICC of 0.91, respectively. Concurrent validity was demonstrated by its significant positive correlations with stigma, depression, and anxiety, as well as significant negative correlations with social support,

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family functioning, and positive caregiving experiences.

Conclusion: The two-factor PSS-10 has good psychometric characteristics assessing the perceived stress of family caregivers of people with schizophrenia. The findings indicate that the PSS-10 can be used to measure perceived stress in future research and practice among caregivers of people with schizophrenia, and potentially, other caregiving samples.

Keywords: 10-item Perceived Stress Scale (PSS-10), psychometric testing, reliability, validity, exploratory factor analysis (EFA), confirmatory factor analysis (CFA)

Strengths and limitations of this study

1. The first study to validate the most widely used 10-item Perceived Stress Scale (PSS-10) among a most stressed yet understudied population--- family caregivers of people with schizophrenia.

2. The factor structure of PSS-10 was tested by randomly dividing the sample into two groups for both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA).

3. An exhaustive testing of multiple psychometric properties of the PSS-10 including EFA, CFA, internal consistency, test-retest reliability, convergent validity, discriminant validity, and concurrent validity.

4. The cross-sectional design of the study may preclude testing of sensitivity to

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change for the PSS-10.

Psychometric validation of the Perceived Stress Scale (PSS-10) among family caregivers of people with schizophrenia in China

Introduction

Schizophrenia is a severe, debilitating chronic psychiatric disorder that causes impairments in cognition, speech, thinking, and emotional responsiveness [1]. It impairs individuals' social and occupational functioning, as well as limits their ability to carry out daily activities [2]. For instance, Wiersma et al. (2000) conducted a 15-year multicenter survey in Europe and found that social dysfunction was widespread and persistent in schizophrenia [3]. Similar findings were also reported in China [4]. Consequently, people with schizophrenia often require ongoing support and care, which in many Asian countries, is often provided by family members [5]. In China, efforts have been made to establish community-based rehabilitation services for people with schizophrenia but with family members assuming the major role of caregiving [6]. These family caregivers represent a large and invisible group to substitute for the under-resourced mental health service system to provide high-quality care to people with schizophrenia[7]. Caring for people with schizophrenia can be a demanding activity that challenges the physical and mental health of family caregivers [8]. As a result, family caregivers may report a high level of stress, which can lead to negative health outcomes and reduced quality of life [9].

Studies have shown that the stress experienced by family caregivers of people with

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schizophrenia is higher than for caregivers of people with other prolonged illnesses, which is related to higher psychological distress, depression, and anxiety [10, 11]. Caregivers' stress may also result in conflict among family members and increased family dysfunction [8, 12]. These caregivers also report increased perceived stigma due to their loved one's mental illness [13-15] as well as insufficient social support [13]. For example, family caregivers may report shame due to disruptive public behaviors of the family member with schizophrenia and seek to hide them from the public as much as possible [16, 17]. This can result in social isolation, lack of social support, and social exclusion, which may further aggravate their stress [16, 17]. Thus, it is both important and meaningful to assess their stress levels using reliable and valid scales, which not only helps strengthen our understanding of their mental well-being for further intervention and support but also can guide the assessment of future intervention effects.

The perceived stress scale (PSS) is one of the most widely used measures for assessing perceived stress in the world [18, 19]. The PSS measures the degree to which participants perceive unpredictability, lack of control, or overload in their live. The original PSS included 14 items (PSS-14), which were further abbreviated into two short versions: PSS-10 and PSS-4 [18, 20]. Although the original PSS-14 showed sufficient validity and reliability, the shorter version (PSS-10) has superior psychometric properties and is recommended for research [21]. The PSS-10 has been translated into various languages and validated in various countries, such as Sweden [22], France [23], Korea [24], Mexico [25], the United States[26], Arabia [27], Serbia [28], Germany [29], Viet Nam [30], Brazil [31] and Thailand [32]. The PSS-10 was first translated into

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Simplified Chinese (the language of the Chinese mainland) by Yang and Huang in 2003

[33], and approved by its original developer Dr. Cohen [34]. The Simplified Chinese

version of the PSS-10 (C-PSS-10) has been used with various populations including

university students [35], elderly service workers [36], and cardiac patients [37], but its

psychometric properties among family caregivers of individuals with prolonged

illnesses, such as with schizophrenia, has not been examined in Chinese communities.

In addition, although there are abundant psychometric testing studies on PSS-10,

inconsistencies exist in the results of its factor structure. Although the original

developer considered it as a uni-dimensional measure[18, 20], dozens of subsequent

studies have proposed a two-factor structure[38-40], and there are also a few studies

showing a three-factor structure[41, 42].

Given the lack of validation of PSS-10 among family caregivers of people with

schizophrenia and the conflicting evidence on its factor structure, we conducted the

current study to run a comprehensive psychometric testing on the PSS-10 among a

Chinese community sample of family caregivers of people with schizophrenia.

Specifically, we tested the factor structure of PSS-10 by randomly dividing the sample

into two groups for exploratory factor analysis (EFA) and confirmatory factor analysis

(CFA), respectively. In addition, we examined other psychometric properties of PSS-

10 including internal consistency reliability, test-retest reliability, convergent validity,

discriminant validity, and concurrent validity.

Materials and methods

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Participants and procedure

This cross-sectional study used baseline data from a large community sample who agreed to participate in an intervention to support family caregivers of people with schizophrenia [43]. A total of 449 family caregivers of people with schizophrenia were recruited from 12 communities affiliated with the Changsha Psychiatric Hospital through the "686 program". "686 program" is China's largest demonstration project aimed at integrating hospital and community services for serious mental illness [44]. The Changsha Psychiatric Hospital has provided mental health services to the 12 communities, including free antipsychotic medicine delivery. Every month, a medical team from the Changsha Psychiatric Hospital went to each community health center to distribute free medicine and run routine health check-ups for registered clients with serious mental illnesses. Inclusion criteria of family caregivers were: 1) caring for a family member registered in the "686 program" and satisfied the Chinese classification of Mental Disorders (CCMD-3) or the international classification of Schizophrenia (ICD-10) criteria for schizophrenia; 2) living with the care recipient for at least the last two years; 3) aged ≥ 18 years; 4) able to read and communicate and complete the questionnaire. Exclusion criteria included: 1) care recipient not registered in the 686 program; 2) care recipient diagnosed with a mental illness other than schizophrenia, such as depression and epilepsy; 3) care recipient living alone; 4) family caregiver having a serious physical or mental illness and thus were unable to communicate and complete the interview; 5) family caregiver younger than 18 years. Our final sample size was 449 participants, satisfying the sample size requirement of at least 10

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participants for each item in psychometric testing of scales [45].

Data collection was conducted from May 2019 and September 2019. Family caregivers were approached during the free medicine delivery process by the medical team and invited to participate in the study. The medical team explained in detail about the study and referred interested caregivers to our research team. The research team fully explained the research to each family caregiver and fully informed the benefits and risks of participation, as well as their right to withdraw at any time. After providing written informed consent, the caregivers received face-to-face interviews conducted by our research team and completed a battery of questionnaires. The entire interview took approximately 20-40 minutes, and each participant was reimbursed RMB 20 yuan (USD 2.80) for the completion of the questionnaire.

Patient and Public Involvement Statement

None

Instruments

Perceived stress scale (PSS-10)

The 10-item perceived stress scale (PSS-10) is a self-assessed measure of psychological stress experienced over the past 30 days[18, 20]. The scale includes 6 negative items (item 1,2,3,6,9,10) assessing the degree of lack of control and negative reactions (also named as negative stress, perceived helplessness, or perceived stress), as well as 4 positive items (item 4,5,7,8) assessing one's ability to cope with existing stressors (also named as positive stress, perceived efficacy, or perceived control) [37, 46]. Each answer is scored on a 5-point Likert scale ranging from 0 (never) to 4 (very

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often) and the 4 positive items are reverse-coded so that higher scores indicate higher stress. The total score of PSS-10 ranges from 0 to 40, with higher scores indicating greater perceived stress and scores of 10 or more indicating moderate to high perceived stress [47]. The Chinese version of PSS-10 used in the present study showed satisfactory internal consistency, with a Cronbach's α of 0.79.

Perceived Devaluation and Discrimination Scale (PDD)

The 12-item Perceived Devaluation and Discrimination Scale (PDD), originated from the Link disease stigma scale series, is a widely used scale for measuring perceived stigma [48-50]. The PDD includes two factors: devaluation (5 items) and discrimination (7 items). Each item is scored on a 5-point Likert scale ranging from 1 (fully agree) to 5 (totally disagree). Items 1, 2, 3, 4, 8, and 10 are reverse-coded. The total score ranges from 12 to 60, with higher scores indicating higher levels of perceived stigma [51]. The PDD showed good reliability with a Cronbach's alpha of 0.78 in the original study[48]. The Chinese version of PDD also showed good reliability in other studies[52]. In the current study, the PDD showed acceptable internal consistency with a Cronbach's alpha of 0.70.

Patient health questionnaire (PHQ-9)

The 9-item Patient Health Questionnaire (PHQ-9) is one of the most widely used screening tools for assessing depressive symptoms over the previous two weeks [53]. Each item is scored on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 27, with higher scores indicating more severe depressive symptoms and a cutoff value of 10 distinguishing between depression

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and non-depression. The PHQ-9 was first translated into Chinese by Yeung et al. in 2008 and showed good reliability and validity in the Chinese population [54]. The Chinese version of PHQ-9 shows good internal consistency in the current study, with a Cronbach's Coefficient of 0.93.

Generalized anxiety disorder scale (GAD-7)

The 7-item Generalized Anxiety Disorder scale (GAD-7) is one of the most widely used screening tools for assessing anxiety symptoms during the previous two weeks [55]. Each item is scored on a 4-point Likert scale ranging from 0 (not at all) to 3 (nearly every day). The total score ranges from 0 to 21, with higher scores indicating more severe anxiety symptoms and a cutoff value of 10 distinguishing between anxiety and non-anxiety [56]. The GAD-7 was first translated into translated it into Chinese by He X et Al. [57], and showed good reliability and validity in the Chinese population[58]. The Chinese version of GAD-7 showed good internal consistency in the current study, with a Cronbach's Coefficient of 0.95.

Multidimensional scale of perceived social support (MSPSS)

The 12-item perceived social support multidimensional scale (MSPSS) is a widely used scale to measure the strength of support respondents received from three different sources: family, friends, and significant others [59]. Each item is scored on a 7-point Likert scale ranging from 1 (very strongly disagree) to 7 (very strongly agree). The total score ranges from 12 to 84, with higher scores indicating higher social support [59, 60]. The MSPSS was first translated into Chinese by Huang L et al in 1996[61]. It showed good reliability with a Cronbach's alpha of 0.85-0.91in the original study [60]. The

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Chinese version of MSPSS in the current study showed good internal consistency with a Cronbach's Coefficient of 0.95.

Family adaptation, partnership, growth, affection, and resolve index scale (APGAR)

The 5-item Family adaptation, partnership, growth, affection, and resolve index scale (APGAR) is a widely used scale to measure one's satisfaction with their family functionality. Each item is scored on a 3-point Likert scale ranging from 0 (almost never) to 2 (almost always) [62]. The total score ranges from 0 to 10, with a higher score indicating higher satisfaction with family functioning. The APGAR has been widely used and well-validated in many previous studies, with Cronbach α of 0.86 in the initial rating [63-65]. The Chinese version of APGAR in the current study showed good internal consistency with a Cronbach's Coefficient of 0.95.

Caregiving rewarding feelings (CRF)

The 12-item caregiving rewarding feelings (CRF) measures the positive emotions of caregivers during the care of a family member with schizophrenia. CRF was initially developed based on qualitative interviews with 30 primary caregivers of people with schizophrenia, then validated in a larger sample. The development and validation of the CRF have been described elsewhere [66, 67]. Some sample items include whether caring for a family member with schizophrenia makes them become "more loving and patient" "gain a lot of respect " "more active and optimistic, " "more responsible". Each item is scored on a 4-point Likert scale ranging from 0 "never" to 3 "nearly always".

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The total score ranges from 0 to 36, with higher scores indicating more positive feelings. The CRF in the current study showed good reliability with a Cronbach's alpha of 0.96.

Statistical analyses

Amos 22.0 (SPSS Inc., Chicago, IL, USA) and IBM SPSS statistics 23 (IBM, Armonk, New York, America) were used for statistical analyses. The sociodemographic characteristics of the samples were examined using descriptive statistics, including mean and standard deviation (SD) for continuous variables, and frequency and percentage for categorical variables.

The factor structure of the PSS-10 was evaluated by both exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). The total sample was randomly and equally divided into group 1 for EFA to build the model and group 2 for CFA to verify the model. Kaiser–Meyer–Olkin (KMO) and Bartlett's test of sphericity were used to test whether our data were suitable for factor analysis[68]. In EFA, principal component factor analysis with oblique rotation was conducted to assess the underlying structure of the PSS-10. Factors were extracted based on two criteria: (1) factors with eigenvalues greater than 1, and (2) items with factor loadings greater than 0.40[68, 69].

The theoretical model identified in EFA was further tested by CFA using the second sample. Kline and Byrne suggested the following CFA goodness-of-fit measures for model fit evaluation: goodness-of-fit index (GFI) >0.9, adjust goodness-of-fit index(AGFI)>0.9, comparing fit index (CFI)>0.9, non-normal fit index (NNFI)>0.90, standard root mean square residual (SRMR)<0.08, root mean square error of

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approximate (RMSEA)<0.08, Tucker-Lewis Index (TLI)>0.9[70-72]. Once a good fit was established, construct validity was further tested by calculating the following indicators: standard regression weight (SRW), average variance extracted (AVE), and composite reliability (CR). According to Hair et al. [73], SRW $\geq$0.50, AVE $\geq$0.50, and CR$\geq$0.70 indicate good convergent validity, while AVE for each construct greater than the squared inter-construct correlations indicates good discriminant validity.

Internal consistency reliability was assessed using Cronbach α for the total scale of PSS-10 and its subscales. A Cronbach α level of $\geq$ 0.70 indicates good reliability [74]. Test-retest reliability was calculated in a subsample of these participants (n =25) who were randomly assessed again 2 weeks later to allow calculation of the intraclass correlation coefficient (ICC). An ICC value of $\geq$ 0.75 indicates good test-retest reliability[75, 76].

Concurrent validity of the PSS-10 was assessed using Pearson product–moment correlations with expected significant positive correlations with perceived stigma (as measured by PDD), depression (as measured by PHQ-9), and anxiety (as measured by GAD-7); as well as expected significant negative correlations with social support (as measured by MSPSS), family functioning (as measured by APGAR), and positive caregiving experiences (as measured by CRF).

Results

Sample demographics

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Table 1 shows the socio-demographic characteristics of the sample. The caregivers had a mean (SD) age of 60.90 (12.28) years. Most caregivers were spouses or parents (80.18%), not employed (85.6%), of middle and high school education (61.5%), and married/cohabited (75.7%). Over half were female (54.1%) and had an annual income of lower than 20,000 RMB (56.6%).

Exploratory factor analysis

The underlying factor structure of the PSS-10 was first examined using EFA on the first half sample (N = 218). Kaiser–Meyer–Olkin test showed a KMO value of 0.93, indicating good sampling adequacy. Bartlett's test of sphericity ($\chi 2 = 1896.319$; df = 45, $p < 0.001$) also suggested that inter-item correlations were large enough to perform EFA.

Further EFA yielded a two-factor solution with two initial eigenvalues above 1 (3.48/1.80) and all items with factor loadings >0.40, which satisfied the predetermined factor extraction criteria (Table 2). The two-factor structure accounted for 89.5 % of the total variance in the sample. The first factor was labeled as "perceived efficacy", with an explained variance of 65.6%, and included all 6 negative items, with factor loadings ranging from 0.70-0.82. The second factor was labeled as "perceived efficacy", with an explained variance of 23.9%, and included all 4 negative items, with factor loadings ranging from 0.60-0.78. The inter-factor correlation was 0.60, suggesting overall high inter-correlations between the two factors.

Confirmatory factor analysis

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The two-factor structure of PSS-10 identified in EFA was further tested using CFA on the second half sample (N=218). The two-factor structure was supported by the following goodness-of-fit statistics: $\chi 2$ /df= 2.628<3, p < 0.001; GFI=0.963; AGFI=0.937; CFI=0.972; NNFI=0.961; TLI=0.961; RMSEA=0.061; SRMR=0.061. All these indexes indicated a good or acceptable model fit. Figure 1 shows a visualization of the two-factor model.

Table 3 shows correlations between CFA factors, Composite Reliability (CR), and Average Variance Extracted (AVE). The two subscales of the PSS-10 were all significantly associated with the total PSS-10 scale as well as each other, with correlation coefficients >0.50, indicating a large effect size. The CFA demonstrated good convergent validity of the PSS-10, with statistically significant SRW >0.50 (0.78-0.92, Table 2), AVE >0.50 (0.79-0.81, Table 3), and composite reliability (CR) >0.70 (0.88-0.94, Table 3). In addition, the CFA also confirmed good discriminant validity of the CRF, with each factor AVE estimate being higher than the squared inter-construct correlations with which it was associated (Table 3).

Reliability

Internal consistency reliability, as measured by Cronbach's alpha coefficient, was 0.79 for the total score of the PSS-10, 0.88 for the subscale of perceived helplessness, and 0.79 for the subscale of perceived efficacy. These results indicate good internal consistency reliability. The ICC for the total score was 0.91 (p < 0.001), exceeding the recommended standard of 0.75 and indicating good test-retest reliability.

Concurrent validity

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The concurrent validity of PSS-10 was verified using correlational analysis. As shown in Table 4, the scores of PSS-10 and its two subscales were significantly positively correlated with PDD (r: 0.07 to 0.16), PHQ-9 (r: 0.17 to 0.54), and GAD-7 (r: 0.14 to 0.62). The scores of PSS-10 and its two subscales were significantly negatively correlated with MSPSS-12 (r: - 0.24 to - 0.13), APGAR-5 (r: - 0.35 to - 0.19), and CRF-12 (r: - 0.45 to - 0.33). All the correlation coefficients were significant at p = 0.01, which confirmed the concurrent validity of PSS-10.

Discussion

PSS-10 is one of the most widely used scales for stress assessment and has been translated into more than 20 languages [21]. However, PSS-10 has never been validated among family caregivers of people living with schizophrenia in China, an important yet understudied population that has been providing free and high-quality care to their loved ones with schizophrenia. In addition, factor analysis of the PSS-10 by previous studies has shown inconsistencies in its factor structures, with one, two, and three factors being proposed. This study tested the psychometric properties of the Chinese version of PSS-10 among family caregivers of people with schizophrenia, with a focus on factor analysis by randomly dividing the sample into two groups for EFA and CFA.

Our results supported a two-factor structure of the PSS-10, with EFA yielding a two-factor structure, which was further verified by CFA with satisfactory model fit. Convergent validity was supported by high SRW, AVE, and construct reliability (CR), while discriminant validity was confirmed by higher AVE estimates than the squared

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inter-construct correlations. Overall, the PSS-10 showed good internal consistency with

a high Cronbach α coefficient, and good test–retest reliability with a high ICC. The

concurrent validity of the pss-10 was also supported by its significant positive

correlations with stigma, depression, and anxiety, and significant negative relationships

with social support, family functioning, and caregiving rewarding feelings. Thus, the

two-factor PSS-10 demonstrated psychometrically sound properties for assessing the

subjective experience of stress among caregivers of people with schizophrenia.

Our preliminary exploratory factor analysis showed a two-factor structure of PSS-

10: perceived helplessness and perceived efficacy. Perceived helplessness includes 6

negative phrasing items (items 1,2,3,6,9,10) that reflect a lack of control and negative

emotions, while perceived efficacy includes 4 positive phrasing items (items 4,5,7, 8)

that reflect confidence in dealing with things and positive emotions. Also, in line with

our theoretical hypothesis, all items of PSS-10 had high factor loadings on their

specified factors, further showing the robustness of the two-factor structure of the PSS-

10. Subsequent confirmatory factor analysis also showed favorable model fit indices,

further corroborating the two-factor structure of PSS-10. In addition, the CFA also

demonstrated good convergent validity of the CRF, with statistically significant

SRW >0.50, AVE >0.50, and construct reliability (CR) >0.70, as well as good

discriminant validity, with each factor AVE estimate being higher than the squared

inter-construct correlations. Our findings were consistent with previous research

showing a similar two-factor structure of PSS-10 in other populations, such as

university students [35, 55, 77], general adult samples [34, 36, 78-80], and clinical

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patients [37, 81]. What is noteworthy is that there has been wide debate about whether

PSS-10 should be used as a full scale [20, 31, 34], or two separate subscales. Some

researchers believe that the two subscales measure different components of the stress

experience [80] and have suggested using them separately [82]. In the current study,

the high correlation coefficient of 0.60 between the two subscales implies that the two

factors are highly correlated yet not redundant with each other. As a result, it is

suggested the PSS-10 can be used as a whole scale or as two subscales depending on

the research questions under study.

The Cronbach α value for the total scale and two subscales of PSS-10 exceeded the

recommended 0.70. indicating high internal consistency reliability. This finding is

consistent with previous studies of Chinese [34-36] and non-Chinese samples, such as

Japan [83], South Korea [84], the United States [85], and Sweden [22]. High test–retest

reliability was supported by a high ICC of the total score, also showing the stability of

PSS-10 in assessing perceived stress over time. However, test–retest reliability findings

must be interpreted with caution because of the relatively small sample size. Future

research may benefit from using a larger sample size to examine test–retest reliability.

The concurrent validity of PSS-10 was demonstrated by its significant positive

correlations with PDD, PHQ-9, and GAD-7, as well as significant negative correlations

with MSPSS12, APGAR, and CRF. This finding is consistent with previous studies

showing negative health outcomes related to high perceived stress among caregivers of

people with schizophrenia, such as increased depression and anxiety, decreased family

functioning and rewarding feelings, which may be related to their increased feelings of

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stigma and reduced social support [11, 13, 26] Understanding the relationship between perceived stress and health outcomes of family caregivers may guide further family caregiver interventions.

The present study also had several limitations. First, the sample was recruited from 12 urban communities of Changsha city and thus may not be representative of other areas, especially rural communities. Future multi-center studies may address this issue. Second, the cross-sectional design of the study may preclude testing of sensitivity to change for the PSS-10; subsequent longitudinal research should examine this. Third, test-retest reliability was based on a relatively small sample size, which may be further confirmed in a larger sample.

Conclusion

In summary, the PSS-10 has good psychometric characteristics assessing the perceived stress of family caregivers of people living with schizophrenia, including good internal consistency, test-retest reliability, convergent validity, discriminant validity, and concurrent validity. Both exploratory factor analysis and confirmatory factor analysis supported a two-factor structure: perceived helplessness and perceived efficacy in the current population. Our findings provide reliable evidence for the use of PSS-10 in future studies to assess perceived stress among caregivers of people living with schizophrenia, and potentially, other caregiving samples.

Acknowledgments

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions:

All authors have made substantial contributions to the study conception and design, data collection and analysis, as well as to the development and editing of the manuscript. XT, SJX, and YY contributed to the conception and design of the study, XT, SJX, FZ, DW, XL, and YY contributed to the research conduction and data collection, XT, SJX, and FZ contributed to data analyses, DW, XL, XT, SJX, and YY contributed to data interpretation. XT and SJX drafted the article while XT, XSJ, FZ, DW, XL, and YY critically appraised it and revised it. All authors approved the final version of the manuscript for submission and publication and agreed to be accountable for all aspects of the work.

Ethics approval and consent to participate

The Institutional Review Board of Xiangya School of Public Health Central South

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University (No.: XYGW-2019-029) has approved and regulates the ethical execution

of this research.

Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the

corresponding author upon reasonable request.

Consent for publication

Not applicable.

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Table 1. Demographic characteristics of the participants (N = 449)

characteristics		M(sd)/N(%) N=449
Age(years)	18-59	169(37.6)
	60-100	280(62.4)
	Mcan(SD)	60.90(12.28)
Gender	Male	206(45.9)
	Female	243(54.1)
Occupation	Employed	65(14.4)
	Not Employed	384(85.6)
Education	Primary and below	130(29.0)
	Middle and high	276(61.5)
	College and above	43(9.5)
Marital Status	Single	19(4.2)
	Married/cohabited	340(75.7)
	Else(divorced/separated/windowed)	90(20.0)
Kinship	Parents	254(56.57)
	Spouse	106(23.61)
	Children	29(6.46)
	Siblings	49(10.91)
	Other	11(2.45)
Income(RMB/year)	20000 or less	254(56.6)
	20001-40000	99(22.0)
	40000 or geater	96(21.4)

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Table 2.   Exploratory factor analysis of the PSS-10 (N=218)

Short item names	Mean (SD)	Components of the factors		Uniqueness	SRW
		Perceived helplessness	Perceived efficacy		
3. Nervous and stressed	2.02 (1.15)	0.82		0.22	0.83
2. Unable to control	1.80 (1.20)	0.78		0.24	0.78
1. Been upset	1.75 (1.09)	0.77		0.21	0.85
10. Could not overcome	1.80 (1.20)	0.75		0.13	0.90
6. Could not cope	1.78 (1.09)	0.71		0.22	0.83
9. Been angered	1.74 (1.24)	0.70		0.14	0.84
8. On top of things	1.91 (1.18)		0.78	0.25	0.91
7. Control irritations	1.74 (1.11)		0.66	0.24	0.84
5. Going your way	2.30 (1.17)		0.63	0.32	0.85
4. Felt confident	1.68 (1.23)		0.60	0.32	0.92
Eigenvalue		3.48	1.80		
Variance (Total = 89.5%)		65.6%	23.9%		
Inter-factor correlation			0.60		

SRW: standard regression weight

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Table 3. Correlations between PSS-10 factors, Composite Reliability (CR), and Average Variance Extracted (AVE) (N=218)

Factors	1	2
1. Perceived helplessness	1	
2. Perceived efficacy	0.60	1
AVE	0.79	0.81
CR	0.94	0.88

CR: Composite reliability, AVE: Average variance extracted

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Table 4 Correlations of PSS-10 and its two subscales with other variables (N=449)

Variables	1	2	3	4	5	6	7	8	9
1. PSS-10	1.00								
2. Perceived helplessness -sub	0.88**	1.00							
3. Perceived efficacy -sub	0.51**	0.09	1.00						
4.PDD	0.16**	0.14**	0.07	1.00					
5. PHQ-9	0.54**	0.54**	0.17**	-0.02	1.00				
6. GAD-7	0.62**	0.65**	0.14**	0.01	0.72**	1.00			
7.MSPSS-12	-0.22**	-0.13**	-0.24**	-0.31**	-0.11*	-0.09	1.00		
8.APGAR-5	-0.30**	-0.19**	-0.35**	-0.27**	-0.18**	-0.17**	0.56**	1.00	
9.CRF-12	-0.33**	-0.15**	-0.45**	-0.27**	-0.12**	-0.08	0.54**	0.66**	1.00

&Spearman correlation using pairwise deletion for missing values *$P< 0.05$, ** $P<0.01$

PSS: Perceived stress scale; PDD: Perceived Devaluation and Discrimination Scale: PHQ-9: Patient health questionnaire-9; GAD-7: Generalized anxiety disorder scale-7; MSPSS: Multidimensional scale of perceived social support; APGAR: Family adaptation, partnership, growth, affection, and resolve index scale; CRF: Caregiving rewarding feelings

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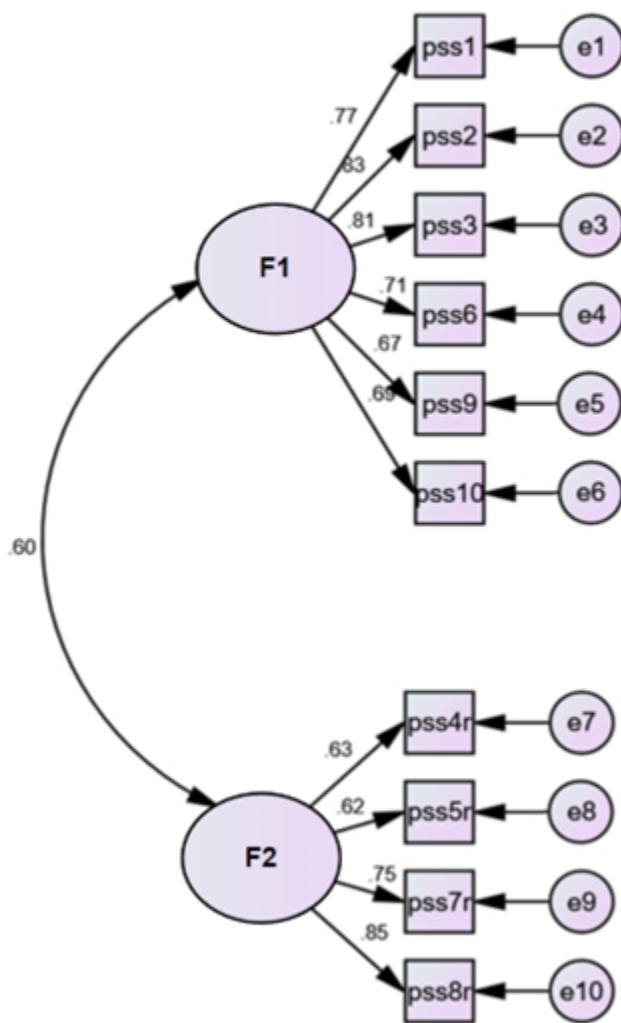**FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10)（N=218）. F1: perceived stress; F2: perceived efficacy; pss: perceived stress scale.**

FIGURE 1 | Standardized factor loadings for the two-factor model of the Perceived Stress Scale (PSS-10)（N=218）. F1: perceived stress; F2: perceived efficacy; pss: perceived stress scale.

117x146mm (96 x 96 DPI)

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3-5
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	6-8
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	9-13
Bias	9	Describe any efforts to address potential sources of bias	NA
Study size	10	Explain how the study size was arrived at	8-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	13
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	13-14
		(*b*) Describe any methods used to examine subgroups and interactions	13-14
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	13-14
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	14
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	14
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	14-15

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	NA
		(*b*) Report category boundaries when continuous variables were categorized	14-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	14-15

Discussion

Key results	18	Summarise key results with reference to study objectives	18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	17-18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18

Other information

| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 19 |

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.